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INJECTOR FOR FUEL INJECTION SYSTEMS OF INTERNAL COMBUSTION ENGINES, IN PARTICULAR DIRECT-INJECTION DIESEL ENGINES

[0001] Prior Art

[0002] The invention relates to an injector as generically defined by the preamble to claim 1.

[0003] An injector of this generic type has been disclosed by German Patent DE 195 19 191 C2. In the subject of that patent, the piezoelectric actuator and booster piston are seated on the upper end of the injector body, and the force transmission to the nozzle needle, located on the lower end of the injector body, is effected via a long tappet. The tappet is in hydraulic communication with the fuel inflow. A pressure conduit machined into the injector body leads to the nozzle outlet. An annular chamber surrounding the tappet in its lower region is also provided, at which a fuel return conduit originates. The fuel return conduit communicates hydraulically with an inner chamber, extending above the tappet, of the booster piston. A control chamber embodied below the booster piston is supplied from the fuel inflow via a leakage gap surrounding the tappet in the injector body.

[0004] The known injector is complicated in its construction and is composed of comparatively many components and does not meet the stringent demands made of modern fuel injection systems, in particular common rail systems for diesel engines.

[0005] Advantages of the Invention

[0006] With the prior art described above as the point of departure, it is the object of the present invention to create an injector that is (also) suitable for common rail systems, that is comparatively simple in construction, that makes do with a minimum number of individual parts, and that operates efficiently.

[0007] According to the invention, this object is attained in an injector of the type defined at the outset by the definitive characteristics of claim 1.

[0008] Advantageous features of the fundamental concept of the invention are contained in claims 2 through 9.

[0009] A substantial advantage of the invention resides in the direct control of the nozzle needle by the piezoelectric actuator. The speed of the nozzle needle motion can be adjusted via the course of voltage of the piezoelectric actuator. For metering especially small preinjection quantities, a partial stroke may also be predetermined. A further advantage, particularly over the known injector of DE 195 19 191 C2, that the injector of the invention has is also considered to be that it makes do without a fuel return.

[0010] Drawing

[0011] The invention is illustrated in terms of an exemplary embodiment in the drawing and described in detail below. Shown (in each case schematically) are:

[0012] Fig. 1, one embodiment of a direct-controlled common rail injector with a piezoelectric actuator, in vertical longitudinal section; and

[0013] Fig. 2, a lower portion of the injector of Fig. 1, in an enlarged view compared to Fig. 1.

[0014] Description of the Exemplary Embodiment

[0015] Reference numeral 10 designates a cylindrical injector body, with a continuous cylindrical recess 11 extending over the majority of the length of the injector body. On its upper end, the recess 11 has first a conically narrowing portion 12, which changes over to a portion 13, 14 that is bent at a right angle and finally discharges to the outside. Located in the cylindrical portion 15 of the recess 11 is a likewise cylindrical piezoelectric actuator 16 of comparatively great length, whose diameter is less than the inside diameter of the recess portion 15. This creates an annular chamber 17 between the outer wall of the piezoelectric actuator 16 and the inner wall of the injector body 10. For the requisite centering of the piezoelectric actuator 16 inside the injector body 10, the conical portion 12 of the axial recess 11 is used, for one thing. For another, as

needed, fluid-passable shims (not shown) may be provided in the annular chamber 17, at defined axial spacings from one another.

[0016] The upper, angled portion 13, 14 of the recess 11 functions as a cable leadthrough for the supply of current to the piezoelectric actuator 16.

[0017] On the upper end of the injector body 10, a fuel supply 18 is provided, such as a high-pressure connection of a common rail system, and it is in hydraulic communication with the annular chamber 17 via a pressure conduit 19.

[0018] The lower end of the injector body 10 is adjoined coaxially by a nozzle body 20, which receives a nozzle needle 21. The nozzle body 20 is secured to the injector body 10 by means of a union nut (clamping nut) 22, in such a way that it comes sealingly to rest, with a rear end face 23, on a lower end face 24 of the injector body 10.

[0019] For receiving the nozzle needle 21, the nozzle body 20 has an inner chamber 25 that is open toward the top and is stepped several times and toward the bottom forms a conical valve seat 28 that discharges into two nozzle outlet bores 26, 27. The valve seat 28 cooperates with a conical end portion 29 of the nozzle needle 21, which end portion functions as a closing body.

[0020] On its upper end, the nozzle needle 21 has a portion 30 of larger diameter, which is fitted into a cylindrical inner chamber 31 of a sleevelike booster piston 32 open at the bottom. The upper closure of the booster piston 32 is formed by a collar 33.

A helical compression spring 34, braced on one end on the end face 23 of the nozzle body 20 and on the other on the collar 33 of the booster piston 32, is located in the annular chamber 17 - surrounding the booster piston 32 - and keeps the booster piston 32 in contact by its face end with the piezoelectric actuator 16. By means of the pressure exerted by the compression spring 34 on the piezoelectric actuator 16 in the direction of the arrow 35 via the booster piston 32, the piezoelectric actuator 16 is sealed off on its top 36 from the injector body 10, and the electrical connection (not shown) can thus be extended to the outside from the injector body 10 through the angled bores 13, 14.

[0021] As the drawing also shows, in the lower part of the nozzle body 20 - as a component of the nozzle body inner chamber 25 - a cylindrical pressure chamber 37 is embodied, which concentrically surrounds the nozzle needle 21 and communicates hydraulically with the annular chamber 17 of the injector body 10, via bores 38, 39 in the nozzle body 20 and via an annular chamber 40 embodied between the nozzle body 20 and the clamping nut 22.

[0022] A further special feature is that the inner chamber 25 of the nozzle body 20 has a stepped increased diameter 41 at the top, in which the booster piston 32 is guided in such a way that a control chamber 42, embodied in the widened inner chamber portion 41 below the booster piston 32, is in hydraulic communication, via a leakage gap 43 (see in particular Fig. 2), with the annular chamber 17 of the injector body 10. A portion 44 of comparatively small diameter of the nozzle body inner chamber 25 serves to guide the nozzle needle 21 inside the nozzle body 20. This guide fit 44 is also

conceived such that a leakage gap 45 (see in particular Fig. 2) is created. The control chamber 42 thus communicates hydraulically via the second leakage gap 45 with the cylindrical chamber 37, which in turn is subjected to high pressure - via the recesses 38 through 40 - from the annular chamber 17 of the injector body 10.

[0023] Another special feature is that the inner chamber 31, extending above the nozzle needle 21, of the booster piston 32 likewise communicates hydraulically with the annular chamber 17, subjected to high pressure, of the injector body 10, specifically via a lateral bore 46 in the booster piston 32.

[0024] The upper (thickened) portion 30 of the nozzle needle 21 is now guided in the booster piston 32 in such a way that a (further) leakage gap 47 is created (see Fig. 2). Via this (third) leakage gap 47 as well, a hydraulic communication is established between the control chamber 42 and the annular chamber 17, subjected to high pressure, of the injector body 10.

[0025] A further special feature is that a (second) helical compression spring 48 is located in the inner chamber 31 of the booster piston 32 and exerts a force on the nozzle needle 21 that is oriented in the closing direction (arrow 49). Thus by means of the (second) compression spring 48, the nozzle needle 21 is kept closed during the intervals between injection events and when the vehicle is stopped. In Figs. 1 and 2, the opening position of the nozzle needle 21 is shown. It is in this position that the injection event takes place, in which from the cylindrical pressure chamber 37, fuel passes through the

outlet bores 26, 27 to reach the cylindrical combustion chamber (not shown) of the engine.

[0026] The control chamber 42 embodied on the lower end of the booster piston 32 serves the purpose of hydraulic length compensation and serves as a hydraulic booster for the elongation motion of the piezoelectric actuator 16.

[0027] The transporting of fuel from the injector body 10 to the nozzle outlet bores takes place via the (comparatively short) recess 38 (or a plurality of such recesses) through the nozzle body 20, which connects the injector body 10 with the annular chamber 40 between the clamping nut 22 and the nozzle body 20. From the annular chamber 40, the fuel is conducted through the further (comparatively short) bore 39 (or a plurality of such bores) to the nozzle outlet bores 26, 27.

[0028] The injector described above functions as follows. During the intervals between the individual injection events, there is no current supplied to the piezoelectric actuator 16. If the piezoelectric actuator 16 is then electrically triggered, it elongates and moves the booster piston 32 downward (in the direction of the arrow 49), counter to the force of the two compression springs 34, 48. In the process, the volume of the control chamber 42 is reduced, and the pressure in the control chamber 42 rises. As a result, an opening force (in the direction of the arrow 35) is exerted on the nozzle needle 21. As soon as the opening force exceeds the closing pressure forces and the force of the compression spring 48, the nozzle opens, because the nozzle needle 21 assumes the (upper) position seen in the drawing and thus uncovers the outlet bores 26,

27. Because of the travel boosting by means of the booster piston 32, the nozzle needle 21 can execute a maximal stroke that is markedly longer than the elongation stroke of the electrically triggered piezoelectric actuator 16.

[0029] As soon as the nozzle needle 21 has left the stroke region of the seat throttling (see Figs. 1 and 2), a compensation of the pressure forces acting on it ensues. The piezoelectric actuator 16 must now, via the booster piston 32, keep the pressure in the control chamber 42 only far enough above the high pressure (rail pressure) prevailing at the pressure connection 18 that the resistance of the compression spring 48 is overcome.

[0030] The longest possible triggering duration is determined by the leakage (43, 45, 47) from the control chamber 42.

[0031] If the pressure in the control chamber 42 decreases to the rail pressure, then the nozzle needle 21 executes a motion downward (in the direction of the arrow 49), until with the jacket face of its conical tip 29 it closes the outlet bores 26, 27. For closing the nozzle needle 21, the electrical triggering of the piezoelectric actuator 16 is interrupted. The piezoelectric actuator 16 thereupon compresses, and the pressure in the control chamber 42 drops below the rail pressure. As a result, the nozzle needle 21 experiences the requisite closing forces, and it closes.

[0032] The compression spring 34 in the process prevents the piezoelectric actuator 16 from disconnecting from the booster piston 32. The piezoelectric actuator 16 and the booster piston 32 accordingly remain constantly in the nonpositive-engagement contact position (visible in Figs. 1 and 2) against one another.